ically forced ascent of the air again brings it to the condensation point, and at 8,000 feet, rain may come in summer. The rainfall on the windward side of the coast range occurs in winter, for then the land is more nearly the temperature of the water. In summer, even with the sea-breeze twice as strong, the heated land surface warms the ascending air too rapidly for the occurrence of precipitation. As little moisture is lost in summer on the coast range, the relative humidity is higher in the interior, so that as the strong winds drive up the mountains, there is more moisture available for precipitation. With unusual wind frequency from the north, there are heavy coast rains at intervals of four to ten years, for then the cold coast water is replaced by a warmer current.

Throughout Peru, the trade winds are in control: there is the wet windward slope, the semi-arid interior plateau and the arid leeward coast. The extraordinary inner diversity of climate in the eastern mountains is due to the difference in exposure to the trade winds, and to the differences in altitude. The contrasts within the desert coast region are the result of the effect of the topography on the daily sea-breezes of varying strength blowing off the cold Humboldt current.

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SPECIAL ARTICLES

THE DISTRIBUTION OF ENDEMIC SPECIES IN NEW ZEALAND

THE flora of New Zealand is so exceptionally rich in endemic forms that its study promises interesting results if taken up under the modern conceptions concerning the origin of species. It embraces among the angiosperms 902 endemics confined to New Zealand proper against 399 forms of wider distribution, 98 of which are confined to New Zealand and outlying islands. This consideration has induced J. C. Willis to make a statistical study of this flora[1] and to compare it with the results deduced from his similar treatment of the endemic forms of Ceylon.[2]

Willis has proposed a new principle for explaining the distribution of plants in general, which is that "the area occupied by any given species (taken in groups of twenty or so) at any given time in any given country in which there occur no well-marked barriers depends upon the age of that species in that country." This proposition he calls his hypothesis of "age and area." It is intended to convey the idea that adaptation, although it may be of use in determining the frequency of a species within its area, is not in general a factor of wider operation. No results show in the figures which can be attributed to it. Exceptional instances, where this seems to be the case, are almost always the result of changes in environic conditions, made by man, and it is a well-known fact that such rapidly spreading forms invade a country along its roads and railroads, occupying chiefly waste fields and stirred-up soil.

If, however, we leave these out of consideration and concern ourselves only with ordinary wild species, statistical study seems the only means to get average and reliable results. Taken in small groups of, *e. g.*, 10–20 species these statistical results prove to be the same everywhere and in all the larger families. A general cause must govern this phenomenon, a cause which is, at any rate, independent of morphological and biological qualities.

New Zealand is very convenient for determining the area of its species, for the islands are spread out in a long curve running in general north and south for about 1,080 miles, with an average breadth of 100. Therefore longitudinal range can simply be substituted for area and this can be determined by dividing the country by transverse lines at every twenty miles. Moreover, it consists chiefly of two parts: North Island and South Island, which do not show any essential barriers to the spreading of plants, but are separated by a channel broad enough not to be passed by

[1] Dr. J. C. Willis, "The Distribution of Species in New Zealand," *Annals of Botany*, Vol. 30, No. 119, July, 1916.

[2] See the review in SCIENCE, N. S., Vol. 43, No. 1118, pp. 785–787, June, 1916.

species under average conditions. It is assumed that the forms, common to both islands, arrived or originated there before this separation arose.

On any theory some endemic species will be older and others younger. The first may now occupy the whole country, but the latter only parts and the youngest even only small parts of it. Climate and environmental conditions are so uniform throughout the islands that on the theory of natural selection no part of them has a greater chance of producing endemics than others and an equal distribution should be expected. The actual facts, however, contradict this conclusion and show that the endemics with a small distribution are heaped up in the center of the country, whereas toward the north and south they become regularly rarer. The endemics found in the extreme ends are almost only those which occupy the whole or a great part of the range.

This most interesting law of distribution is proven by a series of tables, which elucidate it from different sides and by means of different statistical arrangements. It clearly points to some cause which is independent of the uniform climatic conditions, and also of the special adaptability of the species. It holds for the species of the families and larger general as well as for the whole flora, and for those occurring also outside of the islands as well as for those confined to them. In other words, it governs the distribution of the forms, which originally reached New Zealand from elsewhere and first populated it, as well as that of the native types.

The explanation proposed is this: New Zealand is separated from the nearest land area of important size by an immense stretch of water, and so it is evident that few species can have arrived there in recent times, apart from the influence of man. The species of foreign origin, *i. e.*, of wider distribution, or the "wides" as Willis calls them in opposition to the endemics, must therefore mostly be very old and widely spread all over the islands. This latter fact is borne out by the statistical tables. Now the soundings show, that the shallowest water approaches New Zealand towards the center of the chain of islands. On the view that this place was its last connection with a larger continent, sunk beneath the sea in geological times, we may assume it to be the point from which the spreading of the main part of its present angiospermous flora has begun.

As the wides spread slowly from this center toward the extreme northern and southern parts they must have produced new forms from time to time. The oldest of these may have spread along with them, and now occupy the whole area. The younger forms, however, did not find, as yet, the time to do so; they must still be local forms. About three quarters of the wides, but only one third of the endemics are now found to occupy more than half the length of the chain of islands and this fact shows clearly that the endemics are not better adapted for distribution in New Zealand than the wides.

On the other hand, there are only 30 wides of very local occurrence, *i. e.*, occupying less than 160 miles or 1/6 part of the whole length (1,000 miles), whereas about one third of all the endemics or 296 species are in this condition. It is obvious that for some reason or other the wides could spread, whilst the endemics could not. No theory of adaptation can explain this phenomenon, but it is very simply understood on the ground of Willis's law that the local species are the youngest, and have not, as yet, had the time to secure a wider dispersal on the islands.

I must refrain from dealing with the contents of all the twelve tables and with the discussions of their results. But from the facts adduced it seems evident that the theory of natural selection can not explain the distribution of the angiospermous species of New Zealand, and that this distribution clearly points to some general cause, which must be the same for all families and all arbitrarily chosen groups of plants as well as for the flora of all different countries. The theory of "age and area" seems the only one broad enough to comply with these requirements.

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